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Toxicity, Fluoride

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INTRODUCTION

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Background: Fluoride toxicity is characterized by a variety of signs and symptoms. Poisoning most commonly occurs following ingestion (accidental or intentional) of fluoride-containing products. Symptom onset usually occurs within minutes of exposure.

Fluoride is found in many common household products, including toothpaste (eg, sodium monofluorophosphate), dietary supplements (eg, sodium fluoride), glass-etching or chrome-cleaning agents (eg, ammonium bifluoride), and insecticides and rodenticides (eg, sodium fluoride). Historically, most cases of fluoride toxicity have followed accidental ingestion of insecticides or rodenticides.

Pathophysiology: Fluoride has several mechanisms of toxicity. Ingested fluoride initially

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Pathophysiology: Fluoride has several mechanisms of toxicity. Ingested fluoride initially acts locally on the intestinal mucosa. It can form hydrofluoric acid in the stomach, which leads to GI irritation or corrosive effects. Following ingestion, the GI tract is the earliest and most commonly affected organ system.

Once absorbed, fluoride binds calcium ions and may lead to hypocalcemia. Fluoride has direct cytotoxic effects and interferes with a number of enzyme systems; it disrupts oxidative phosphorylation, glycolysis, coagulation, and neurotransmission (by binding calcium). Fluoride inhibits Na⁺/K⁺ -ATPase, which may lead to hyperkalemia by extracellular release of potassium. Fluoride inhibits acetylcholinesterase, which may be partly responsible for hypersalivation, vomiting, and diarrhea (cholinergic signs). Seizures may result from both hypomagnesemia and hypocalcemia. Severe fluoride toxicity will result in multiorgan failure. Central vasomotor depression as well as direct cardiotoxicity also may occur. Death usually results from respiratory paralysis, dysrhythmia, or cardiac failure.

Mortality/Morbidity:

- Death may result from ingesting as little as 2 g of fluoride in an adult and 16 mg/kg in children. Symptoms may appear with 3-5 mg/kg of fluoride.
- Estimated toxic dose for fluoride ingestion is 5-10 mg/kg.
- Estimated lethal dose is 5-10 g (32-64 mg/kg) in adults and 500 mg in small children.

Age:

- Infants and children usually have accidental exposures.
- Adults usually have intentional exposures.

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History:

- Determine the exact nature and time of exposure or ingestion. Query patient, bystanders, paramedics, and family members regarding specifics of exposure or ingestion.

Physical:

- Gastrointestinal signs predominate
 - Hypersalivation
 - Nausea
 - Vomiting
 - Diarrhea
 - Abdominal pain
 - Dysphagia
 - Mucosal injury

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- **Electrolyte abnormalities**

- Hypocalcemia
- Hypomagnesemia
- Hyperkalemia
- Hypoglycemia

- **Neurologic effects**

- Headache
- Tremors
- Muscular spasm
- Tetanic contractions
- Hyperactive reflexes
- Seizures
- Muscle weakness

- **Cardiovascular**

- Widening of QRS
- Various arrhythmias
- Shock
- Cardiac arrest

Causes:

- The most common type of exposure is ingestion of products that contain fluoride. To obtain the exact name of the product and how much was ingested is extremely important.
- Toothpaste contains 1 mg/g of fluoride as sodium monofluorophosphate. This fluoride formulation has low solubility and is generally nontoxic.
- The toxic effects following large ingestions of the following products usually are limited to GI discomfort.
 - Toothpaste
 - Oral hygiene products
 - Insecticide
 - Rodenticide
 - Dietary supplements
 - Automobile wheel-cleaning products

- Glass-etching products

DIFFERENTIALS

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Lab Studies:

- Serum electrolytes
 - Hyperkalemia
 - Hypocalcemia
 - Hypomagnesemia
 - Hypoglycemia
- Electrocardiogram and cardiac monitoring
 - Effects of hyperkalemia (peaked T waves, widened QRS, bradycardia, atrioventricular [AV] nodal blockade)
 - Effects of hypocalcemia (prolonged corrected QT interval [QTc])
- Serum and urine fluoride levels are not available for ED evaluation.

- Perform a Dextrostix evaluation (fingerstick) on all patients with seizure and altered mental status because of the risk for hypoglycemia with systemic fluoride toxicity.

TREATMENT

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Prehospital Care: Place patients with a known significant ingestion of fluoride on a cardiac monitor and initiate an IV line. Administer calcium IV to patients who present with cardiac dysrhythmias.

Emergency Department Care:

- Provide cardiac monitoring.
- Hypocalcemia may be detected.
- Perform gastric aspiration and lavage. Small-bore nasogastric tube aspiration, followed by lavage, is recommended because of the potential severity of this ingestion and the ineffective absorption of fluoride by activated charcoal. Lavage with milk or a solution containing calcium or magnesium hydroxide (eg, milk of magnesia) is theoretically attractive but has not been proven beneficial. Some recommend lavaging with 1-5% calcium chloride solution to bind fluoride in the stomach.
- Gastric aspiration and lavage are most effective when instituted within 1 hour of ingestion.
- Administer milk, calcium carbonate, and aluminum- and magnesium-based antacids (eg, hydroxides) to bind fluoride.
- Activated charcoal is not helpful. Fluoride does not bind to charcoal. Activated charcoal still is recommended for those with intentional ingestions when a polysubstance overdose is possible.
- Correct calcium deficiencies with IV calcium chloride.

Consultations:

- Consult a toxicologist or poison control center for acute management recommendations.
- Psychiatric consultation is necessary after medical clearance.

MEDICATION

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Goals of therapy are to reduce toxicity and prevent complications.

Drug Category: *Electrolytes* -- Calcium chloride is administered to correct hypocalcemia

that may result from fluoride poisoning. Calcium chloride provides 3 times more calcium than calcium gluconate on an equal-volume basis and is preferred (despite greater tissue toxicity if extravasation occurs).

Drug Name	Calcium chloride -- Manages underlying hypocalcemic effects caused by fluoride poisoning.
Adult Dose	Initial dose: 1-2 g (1-2 ampules) IV slow push of 10% calcium chloride solution (10 mL each); repeat doses to obtain desired serum calcium level; for severe poisoning, may need to give multiple grams for the first several h
Pediatric Dose	20-25 mg/kg IV push of calcium chloride; repeat as necessary; may need massive doses with severe poisoning
Contraindications	Ventricular fibrillation not associated with hyperkalemia; digitalis toxicity, hypercalcemia, renal insufficiency, cardiac disease
Interactions	Coadministration with digoxin may cause arrhythmias; with thiazides, may induce hypercalcemia; may antagonize effects of calcium channel blockers, atenolol, and sodium polystyrene sulfonate
Pregnancy	B - Usually safe but benefits must outweigh the risks.
Precautions	Administer slowly (not to exceed 0.5-1 mL/min) to avoid extravasation; hypercalcemia may occur in renal failure
Drug Name	Calcium gluconate (Kalcinate) -- Moderates nerve and muscle performance and facilitates normal cardiac function. For systemic hypocalcemia, agent can be given IV initially, and then calcium levels can be maintained with high calcium diet. Some patients will require oral calcium supplementation. For topical pain, agent can be applied as a water-soluble gel mixture.
Adult Dose	May apply 2.5-5% calcium gluconate to affected area; repeat as often as required for pain control; if not available commercially, prepare as a simple 3:1 (for 2.5%) or 1:1 (for 5%) dilution of a 10% IV solution in a water-soluble surgical gel or similar sterile base
Pediatric Dose	Apply as in adults
Contraindications	Renal calculi, hypercalcemia, hypophosphatemia, renal or cardiac disease, and digitalis toxicity
Interactions	May decrease effects of tetracyclines, atenolol, salicylates, iron salts, and fluoroquinolones; antagonizes effects of verapamil; large intakes of dietary fiber may decrease calcium absorption and levels
Pregnancy	B - Usually safe but benefits must outweigh the risks.
Precautions	Caution in digitalized patients, respiratory failure, acidosis, or severe hyperphosphatemia; monitor serum calcium when calcium gluconate is administered parenterally

FOLLOW-UP

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Further Inpatient Care :

- Correct electrolyte abnormalities, especially hyperkalemia and hypocalcemia.
- Hemodialysis is used for critically ill patients that are refractory to all other forms of treatment.
- Cardiac arrhythmias are difficult to treat because they do not respond to lidocaine, cardioversion, or defibrillation.

D terrence/Prevention:

- Keep all dangerous household products out of reach of small children.

Prognosis:

- Patients may be discharged if asymptomatic and ingestion is less than 3 mg/kg by accurate history.
- If a patient presents with persistent signs and symptoms, admit to a monitored bed.
- Monitor and watch patients in the ED for 6 hours before possible discharge.
- Delayed clinical presentation of significant exposures is quite common.

MISCELLANEOUS

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Medical/Legal Pitfalls:

- Failure to appreciate potential severity of this exposure

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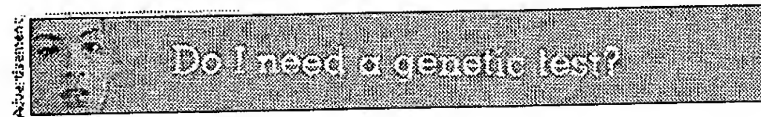
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Medical Content Reviewed by the Faculty of the Harvard Medical School

Gas-Be-Gone

Does Beano work? Are there natural ways to reduce the gas you pass? Try preventive measures first. If they don't work, learn how to move gas through your intestines more readily.

While there are several reasons you may find yourself to be gassy, there are many solutions for reducing belching, flatulence, abdominal bloating and pain.

Excess gas commonly is associated with irritable bowel syndrome. Other serious gastrointestinal disorders usually produce other symptoms besides just being "gassy."

Doctors usually recommend a plan to help move gas through the intestines more readily, combined with preventive measures, such as eliminating certain foods from your diet and avoiding chewing gum.

Although many products on store shelves promise to help, their success is not guaranteed and often depends on the individual. There are also prescription medicines and some alternative therapies.

Keeping a diary of the foods and beverages you consume can help you systematically eliminate one food or group of foods at a time to determine which may be most responsible for your symptoms.

John R. Saltzman, M.D., associate director of endoscopy at Boston's Brigham and Women's Hospital, says this should be the first approach to resolving extreme gas symptoms.

"One of the first questions at the top of the list would be 'Could this be related to dairy products?' If it is, the first step should be to eliminate these products from your diet for about seven days," Dr. Saltzman says. "If you feel better, then try to add dairy products back to your diet in smaller amounts to see if you can tolerate them."

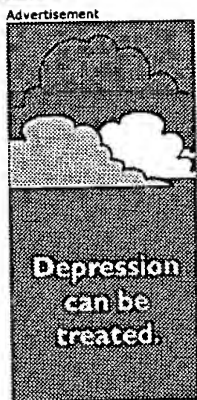
Here are some recommended home remedies and lifestyle changes from Harvard Medical School's Family Health Guide:

- Chew more slowly and thoroughly. Because gas can be a sign of undigested food, the enzymes in saliva begin the first stage of breaking down food in the body's absorption process.
- Eat in a stress-free environment. Relaxation is known to reduce flatulence and burping.
- Avoid foods you know cause indigestion. Common food sources of gas include Brussels sprouts, bran, beans, milk products, cabbage, artificial sweeteners, carbonated beverages and alcohol.
- Take a short walk after you eat to prevent gas accumulation. Maintaining a regular exercise schedule in the form of walking, jogging and calisthenics will help stimulate the passage of gas through the digestive tract.
- Perform chest-to-knee stretches. Lying on your back, bring your right knee to your chest. Hold for 10 seconds and, then repeat with the other knee.

If those remedies don't provide relief, your doctor may recommend that you take an over-the-counter antacid, activated charcoal, or a lactase or bismuth product.

Antacids

Antacids contain aluminum hydroxide, magnesium hydroxide (known as Milk of Magnesia),



calcium carbonate, or other ingredients individually or in various combinations.

"Generally, antacids are not a treatment for excessive gas. However some patients have excessive gas that is part of gastroesophageal reflux disease," Dr. Saltzman says.

Antacids help to control the symptoms of gastroesophageal reflux disease, a condition in which the stomach's juices (acid and digestive enzymes) flow backward, or reflux, into the esophagus.

Some antacids contain simethicone, a foaming agent that joins gas bubbles in the stomach so that gas is more easily burped away. Simethicone is recommended for treating gas in the upper intestine.

"People do use simethicone by itself, even without the antacids," Dr. Saltzman says. "It's safe, worth trying, but not universally beneficial."

Here are some of the commonly used antacids found on store shelves. (See labels for recommended dosages.)

Brand-name antacids without simethicone:

- Maalox
- Mylanta Gas

Brand-name antacids with simethicone:

- Di-Gel

Products with simethicone as the main ingredient:

- Equalize Gas Relief Drops
- Flatulex Drops
- Gas-X
- Little Tummys
- Maalox Anti-Gas
- Micon-80
- Mylanta Gas
- Mylicon
- Mytab Gas
- Phazyme

Activated Charcoal

Tablets of activated charcoal may provide relief from gas in the colon. Studies have shown that when taken before and after a meal, lower-intestinal gas is reduced.

However, activated charcoal can cause black stools and constipation. While these are harmless side effects, black stools can be confusing to a physician, because color changes in stool can be a sign of a serious illness.

"A physician may, in talking to a patient, ask if their stool color changes. If a patient describes a black color of the stool, this may suggest gastrointestinal bleeding," Dr. Saltzman says. "It should be mentioned if you are taking activated charcoal, so we can evaluate the significance of stool color appropriately."

Evidence concerning the benefit of activated charcoal is contradictory. Its effect in alleviating symptoms of intestinal gas has been supported by some studies yet refuted by others. As a result, physicians may recommend that patients consider trying activated charcoal to see whether its use results in some symptom relief. The usual dose is two to four tablets taken just before eating and one hour after meals

Products: CharcoCaps, CharcoAid

Lactase

Gas is often a symptom of lactose intolerance, which makes digesting dairy products difficult. It occurs when the body has too little of the enzyme lactase in the small intestine to break down lactose, the main sugar in milk and milk-based products.

Although lactose intolerance can happen at any age, it tends to affect most people as they grow older.

"Essentially the only adults in the world who can digest milk products into adulthood are those who descend from northern Europe," Dr. Saltzman says. "Most patients with descendants from Asia, Africa and Native America have trouble."

But in many cases, the deficiency of lactase means you may lose only some of your enzyme, which means that your intestine may tolerate some dairy products.

"So if you have yogurt, you may be able to tolerate it fine, but if you have two slices of pizza you are having problems," he says.

Lactase comes in liquid or tablet form. Adding a few drops to milk before drinking or chewing lactase tablets just before eating helps people who have difficulty breaking down lactose.

One caution: Be sure to take calcium supplements if you avoid dairy products.

Products: LactAid, Lactrase, and Dairy Ease

Beano

Beano is an over-the-counter preparation of alpha-galactosidase, an enzyme that metabolizes certain complex carbohydrates. It helps the body digest the sugar in beans and many vegetables.

"We do not have the ability to digest beans well, which in some people causes a lot of gas," Dr. Saltzman says.

Beano is not useful for gas caused by foods other than beans, he adds. The product comes in liquid form. Three to 10 drops are added to a serving of food just before eating to break down the gas-producing sugars.

Bismuth

This chemical element has salts to relieve inflammatory conditions of the stomach and intestines and can sometimes relieve gas. It also reduces the odor of unpleasant smelling gas caused by hydrogen sulfide, a sulfur-containing compound.

"It's safe for gas if the recommended dosage on the box is followed, and it's worth trying," Dr. Saltzman says.

Like activated charcoal, bismuth may result in black stools. Take before or after meals, on either an empty or full stomach.

Product: Pepto-Bismol

Prescription Medications

Your doctor may prescribe medication if you have a motility disorder or irritable bowel syndrome.

Pro-motility drugs (also called pro-kinetic drugs, such as metoclopramide, brand name Reglan) may help gas move through the digestive tract rapidly. However, metoclopramide can have significant side effects.

"One of the big problems I find is that anxiety causes involuntary air swallowing," Dr. Saltzman says. Treating anxiety helps decrease air swallowing and the symptoms of excess stomach gas.

Smoking cigarettes and chewing gum are among the hard-to-break habits that result in an accumulation of gas. But the good news is that this state of discomfort is temporary. "Those symptoms are present during the day and they go away during night," he says.

You may have harmless bacteria that produces gas in the intestines, or sluggish bowels that slow the body's ability to get rid of air. Your doctor may try antibiotic therapy if you have been diagnosed with bacterial overgrowth.


Alternative Therapy

There is medical support for herbal remedies from Harvard's Family Health Guide and the American Gastroenterological Association.


Drinking a cup of water with a drop of peppermint, cinnamon or ginger extract has been known to help patients. Also, relief may be found in chewing fennel seeds, or sipping teas with peppermint, anise or chamomile after a meal.




In summary, stomach and intestinal gas is normal. Excess gas can be distressing, but rarely is it caused by a serious medical disorder. If your symptoms cannot be easily controlled or you have additional problems such as abdominal pain, change in bowel habits, or rectal bleeding, you need to contact your doctor's office.

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